



Importance of dissolved organic carbon flux through submarine groundwater discharge to the coastal ocean: Results from Masan Bay, the southern coast of Korea



Yong Hwa Oh ^a, Yong-Woo Lee ^b, Sang Rul Park ^c, Tae-Hoon Kim ^{d,*}

^a Groundwater and Ecohydrology Research Center, Geologic Environment Division, Korea Institute of Geoscience and Mineral Resources, Daejeon, 34132, Republic of Korea

^b Marine Environment Monitoring Team, Korea Marine Environment Management Corporation, Busan 49111, Republic of Korea

^c Department of Marine Life Sciences, Jeju National University, Jeju 63243, Republic of Korea

^d Department of Earth and Marine Sciences, Jeju National University, Jeju 63243, Republic of Korea

ARTICLE INFO

Article history:

Received 13 September 2016

Received in revised form 1 March 2017

Accepted 3 March 2017

Available online 27 April 2017

Keywords:

Dissolved organic carbon

Submarine groundwater discharge

Subterranean estuary

Mass balance model

Masan Bay

ABSTRACT

In order to estimate the fluxes of dissolved organic carbon (DOC) through submarine groundwater discharge (SGD), salinity and DOC concentrations in groundwater, stream water, and seawater were investigated in May 2006 and 2007 (dry season) and August 2006 (wet season) in Masan Bay, Korea. In both seasons, the average concentrations of DOC in groundwater ($139 \pm 23 \mu\text{M}$ in May and $113 \pm 18 \mu\text{M}$ in August) were relatively lower than those in stream water ($284 \pm 104 \mu\text{M}$ in May and $150 \pm 36 \mu\text{M}$ in August) but similar to those of the bay water ($149 \pm 17 \mu\text{M}$ in May and $117 \pm 13 \mu\text{M}$ in August). The DOC concentrations in groundwater, stream water, and seawater showed negative relationships with salinity, but those in the surface bay water were observed above the theoretical mixing line, indicating that DOC may be produced by *in situ* primary production in this bay. Based on a simple DOC mass balance model, SGD-derived DOC fluxes in Masan Bay were estimated to be $6.7 \times 10^5 \text{ mol d}^{-1}$ in the dry season and $6.4 \times 10^5 \text{ mol d}^{-1}$ in the wet season, showing no remarkable seasonal variation. The DOC fluxes through SGD in Masan Bay accounted for approximately 65% of the total input fluxes. This result suggests that the DOC flux through SGD can be the most important source of DOC in this bay, and SGD may play an important role in carbon budget and biogeochemistry in coastal areas.

© 2017 Elsevier B.V. All rights reserved.

1. Introduction

Submarine groundwater discharge (SGD) has been recognized as an important pathway for transporting organic matter, nutrients, and trace elements to the coastal area comparable to river discharge (Burnett et al., 2003; Moore, 1996; Kim et al., 2012; Kim et al., 2013). SGD is described as any water flow which passes through the sediment into the coastal ocean regardless of composition or driving force (Moore, 2010) and consists of terrestrially derived fresh groundwater and re-circulated saline groundwater (Burnett et al., 2003; Moore et al., 2008). The driving forces of SGD in coastal zones are tidal pumping, wave set-up, terrestrial hydraulic gradients, fluid shearing, density-driven convection, sediment compaction, and bio-irrigation (Santos et al., 2012). Moore (1999) reported that the subterranean estuary (STE), where groundwater passes through with various biogeochemical reactions, is a coastal mixing zone between fresh groundwater and seawater invading through a permeable aquifer. Biogeochemical reactions occurring in STE combined with SGD are known to have a large impact on

coastal budgets of various chemical constituents (Charette and Sholkovitz, 2002; Windom and Niencheski, 2003; Slomp and Cappellen, 2004).

Dissolved organic carbon (DOC), the largest organic carbon reservoirs in the ocean, accounts for an important component of the global carbon cycle (Williams and Druffel, 1987; Hansell and Carlson, 1998; Hansell et al., 2009). Since DOC in coastal zones mainly originates from terrestrial sources such as groundwater or river water and enters the oceans, it is important to investigate origins and fates of DOC for better understanding the carbon cycle. However, there have only been a few studies dealing with its behavior in STEs (Beck et al., 2007; Santos et al., 2009; Kim et al., 2013).

Groundwater-derived DOC flux was underestimated as an important source to investigate the carbon cycle in estuarine systems but has been recognized as an important coastal DOC input source. For example, Kim et al. (2012) reported that DOC flux through SGD in Hampyeong Bay, located on the southern coast of Korea, accounted for 24% of the total SGD-driven dissolved organic matter (DOM) flux into this bay. Sadat-Noori et al. (2016) reported that SGD-derived DOC contributed 41% of carbon exports from a subtropical estuary (New South Wales, Australia). Furthermore, Stewart et al. (2015) reported that

* Corresponding author.

E-mail address: thkim@jejunu.ac.kr (T.-H. Kim).

SGD-derived DOC flux was equivalent to ~38 times the annual delivery via all rivers into Moreton Bay (Queensland, Australia), suggesting that SGD is a major component of hydrological and biogeochemical cycles in the bay. However, the behavior and cycling of DOC in STE were not fully explored, as behavior of DOC shows a large difference in various environments depending on hydrological and climatic conditions.

Masan Bay (Gyeongsangnam-do, Korea) has suffered from domestic and industrial effluents and SGD, resulting in complicated problems including outbreaks of harmful algal blooms (Lim et al., 2006; Kim et al., 2007; Lee et al., 2009). Lee et al. (2009) reported that SGD could play an important role in sources of nutrients and factors controlling the outbreak of phytoplankton blooms, resulting from proportions of dissolved inorganic nitrogen (42–45%) and phosphorus (42–51%) through SGD of the total fluxes in Masan Bay. However, very limited investigation has been conducted on the DOC behavior in STE and SGD-derived DOC flux in this bay. Therefore, the aims of this study were (1) to investigate DOC distribution in different types of water samples (seawater, groundwater, and bay water) in Masan Bay where the discharge of groundwater is an order of magnitude higher than the discharge of stream water and (2) to estimate SGD-derived DOC flux using a mass balance model in different climatic and hydrological conditions (dry and wet seasons).

2. Materials and methods

2.1. Study area

Masan Bay, located on the southeast coast of Korea, is surrounded by industrial complexes and megacities and is semi-enclosed. The previous studies reported that Masan bay was one of the most contaminated

regions in Korea due to sewage and wastewater discharged into the bay (Li et al., 2008; Choi et al., 2009). The annual precipitation of this region is 1560 mm. Three streams (Nam, Changwon, and Samho streams) enter the bay, with a large seasonal variation due to a monsoon climate (KIOST, 2002). The surface sediment of this bay consists mainly of silt and clay (>90%) with small portion of sand (Woo et al., 2003). There are two wastewater treatment plants which treat about 370,000 ton/day and discharge the effluents into Masan Bay (MOE, 2012).

2.2. Sampling

Stream water, groundwater, and seawater samples were collected in May and August 2006 and May 2007 in Masan Bay for the analyses of DOC (Fig. 1). Stream water samples ($n = 2$ in May and $n = 3$ in August) were obtained using a submersible pump (a flow rate of 15–20 L min⁻¹). The groundwater samples ($n = 20$ in May and $n = 7$ in August) were collected from various shallow (<0.5 m) and deeper (<10 m) wells from the shore (<20 m). Bay water ($n = 11$ in May and $n = 10$ in August) and seawater ($n = 1$ in May and August) samples were obtained from the surface (~1 m below the surface) using a submersible pump on shipboard. Samples for the analyses of DOC were filtered using Whatman GF/F filters (0.7 µm) and stored in fire-sealed glass ampoules after acidifying the samples to pH 2 using 6 M HCl. All filters and ampoules were pre-combusted at 500 °C for 5 h (Kim and Kim, 2010). Groundwater level, precipitation rate, and stream water discharge rate were obtained from National Groundwater Information Center (www.gims.go.kr), Korea Meteorological Administration (www.kma.go.kr), and the previous study (Lee et al., 2009), respectively.

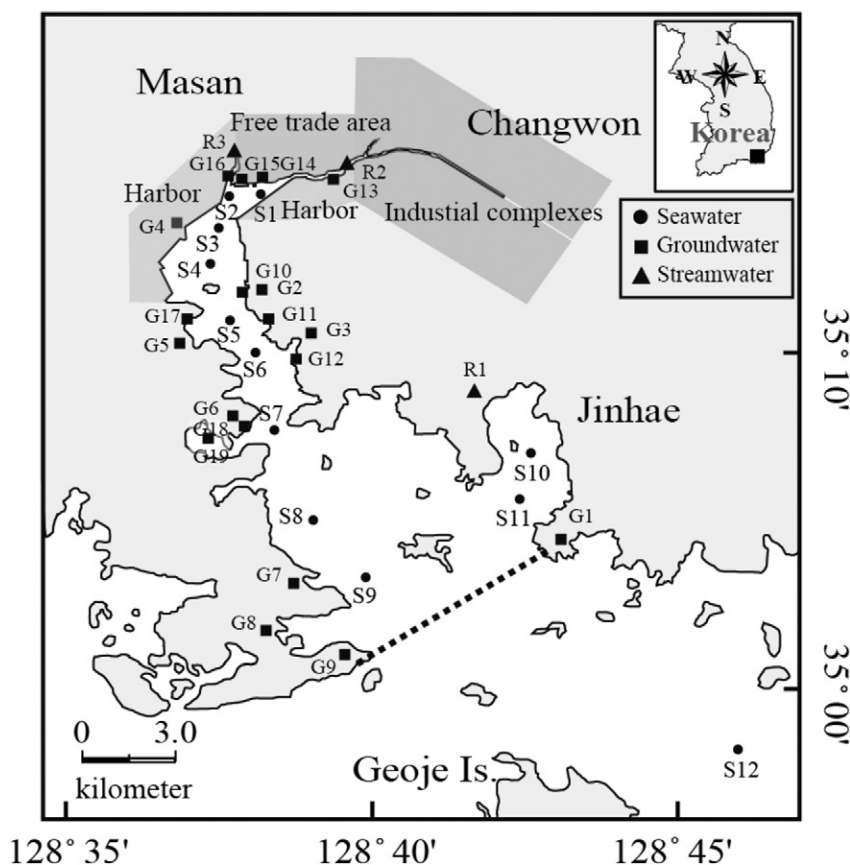


Fig. 1. A map showing groundwater and seawater sampling stations for dissolved organic carbon (DOC) in Masan Bay. Circle, square, and triangle represent sampling stations for seawater, groundwater, and stream water in the bay, respectively.

Download English Version:

<https://daneshyari.com/en/article/5765974>

Download Persian Version:

<https://daneshyari.com/article/5765974>

[Daneshyari.com](https://daneshyari.com)